NIF NEWS
THE NATIONAL IGNITION FACILITY NEWSLETTER

Reliability and Control of the National Ignition Facility Costs and Schedule

Introduction

In January 1993, Secretary of Energy James Watkins authorized Key Decision Zero for the National Ignition Facility (NIF) Project. This action established the Department of Energy's (DOE) mission requirement for an ignition facility like the NIF, and authorized a conceptual design study to determine its cost. The *National Ignition Facility Conceptual Design Report* was prepared by a multidisciplinary team of scientists and engineers from the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory, Sandia National Laboratories, and the University of Rochester. The Conceptual Design Report (CDR), which was completed and submitted to Energy Secretary Hazel O'Leary in May 1994, extensively describes all aspects of the large-laser project, including the scientific basis, design requirements, and proposed conceptual design of all system components. In parallel with documenting the project design, the team established detailed project cost and schedule estimates using several well-established methods. This *NIF NEWS* discusses the processes of establishing reliable and accurate project costs and schedule, and the measures instituted to assure their control.

Defining Project Costs

The DOE defines the cost categories for all DOE-funded projects. The basic cost estimates for locating the NIF Project at a generic DOE site are as follows:

- Total estimated cost—$843 million
- Total project cost—$1074 million

For the NIF Project, the values for both the *total estimated cost* and the *total project cost* are in "as-spent" dollars—simply stated, this means that the actual estimates account for characteristics such as inflation, and the estimates include the projected future costs of items and services. Estimates using "as-spent" dollars are much more realistic than estimates that do not compensate for inevitable escalation characteristics.

As defined by the DOE, the *total project cost* consists of the sum of the *total estimated cost* and *other project costs*. Figure 1 represents these costs and includes a breakdown of the elements in each category.

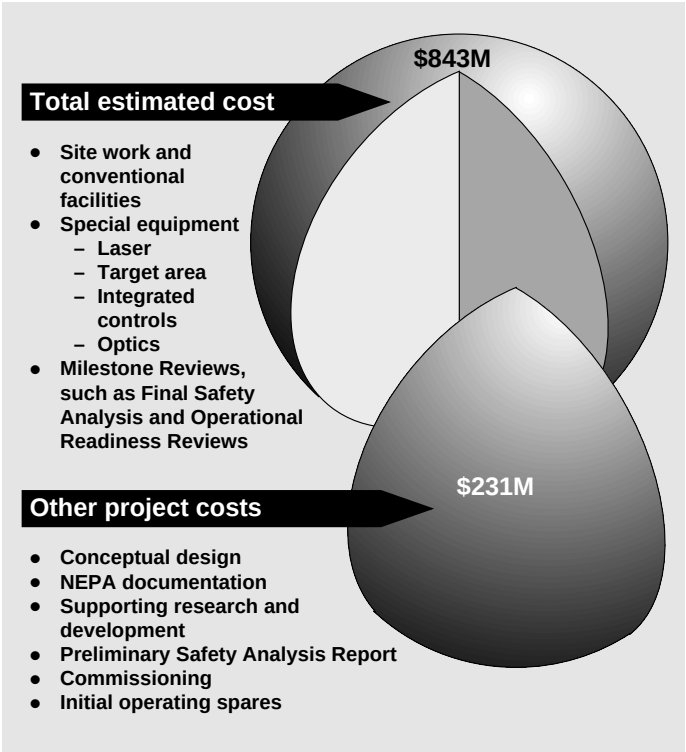

Figure 1. Total Project Cost ($1074 million) consists of the Total Estimated Cost ($843 million) and Other Project Costs ($231 million).

Reliably Estimating Cost and Schedule

The cost- and schedule-estimating teams applied the following mechanisms to develop precise, thorough, and reliable cost and schedule estimates:

Catalogs, databases, and vendor quotes—Almost half of the cost estimates were from catalogs, industry databases, or external vendors. For items with significant uncertainty, we obtained estimates from several potential vendors. Approximately 87% of the total estimated cost was developed through very-high-confidence methods, shown in Figure 2.

Historical experience—Most of the hundreds of contributors to the design report had successfully generated accurate cost and schedule estimates for other large laser projects constructed within budget and schedule estimates. For example, LLNL's Nova laser—the predecessor to the NIF—was constructed within its cost estimate and on schedule. Nova was the fifth large-scale laser facility for which LLNL has successfully estimated project cost and schedule.

Thorough design detail—Detailed component-level engineering drawings and specifications, documented in the CDR and in engineering files, formed the basis for obtaining accurate estimates.

Contingency analysis—To account for uncertainties in estimating costs, the Bechtel Corporation performed a detailed *contingency analysis*, which assessed the likelihood that each component will cost as it was estimated. Bechtel concluded that to have at least a 70% probability that project cost will not exceed estimates, a 21% contingency is required. That amount has been included in the total project cost estimate.

The Integrated Project Schedule was determined in the same manner. LLNL worked with experienced vendors to create a "bottom-up" schedule derived from vendor estimates on component fabrication per specified manufacturing processes. More than 4000 NIF components or subsystems were explicitly included. A series of schedule-versus-cost scenarios (such as what are the effects of shorter or longer manufacturing times on cost?) was analyzed to produce an optimum, minimum-cost project schedule.

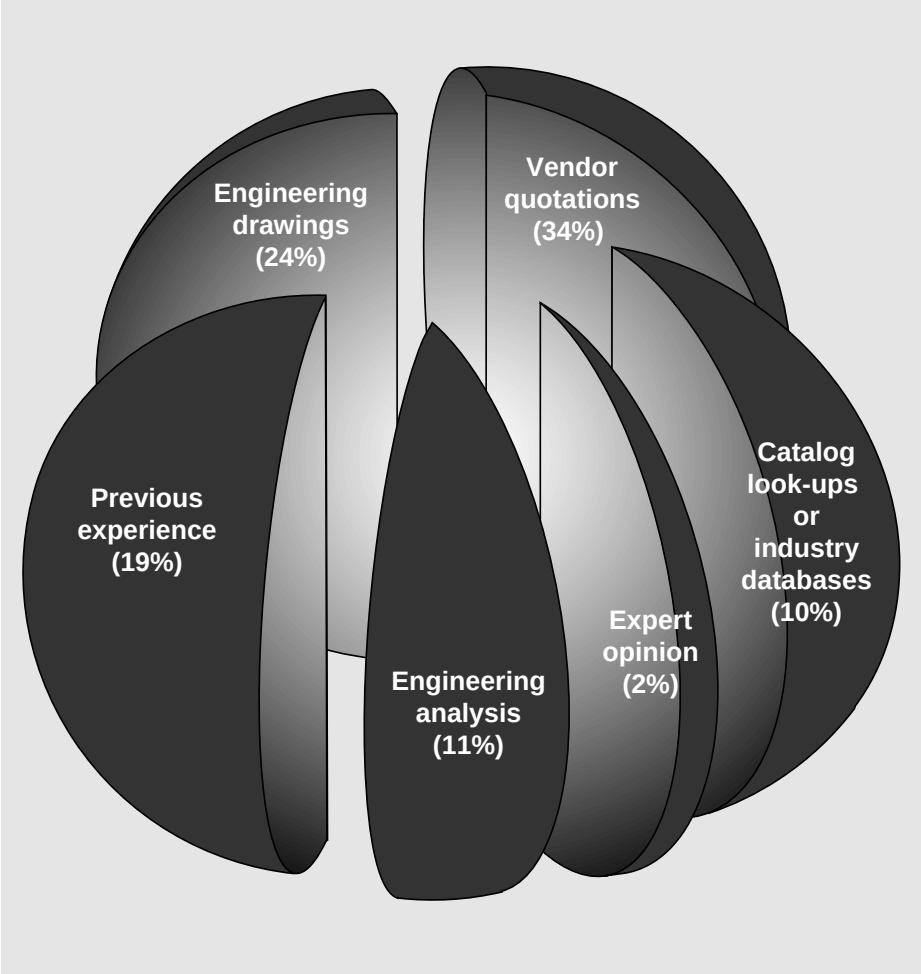

Figure 2. The NIF Project's total estimated cost was developed through very-high-confidence methods.

Validating Projected Laser Performance

To assure that the laser will deliver the required performance, a prototype NIF beam line has been built. The prototype, called the Beamlet laser, consists of a full-scale set of all required hardware, from the photon source to the focusing lens, for one of the NIF's 192 beam lines. The Beamlet, shown in Figure 3, has demonstrated the required laser performance and was built within estimated cost.

The Beamlet Project proved that a single full-scale beam line could be built that would perform as expected. To meet the NIF's estimated costs, mass-production techniques for the thousands of required optical components are being developed and will be implemented for the NIF. These techniques, developed in conjunction with optics manufacturers, are summarized in the *Manufacturing Readiness Plan*. The plan describes the manufacturing processes that must be developed and implemented in order to meet our cost estimates for optics components.

The Bechtel Corporation performed a probability analysis for the plan and assessed the monetary risk to account for potential failures in any of the newly developed manufacturing processes. Using this approach, Bechtel concluded that there would be less than 2% total cost exposure if the *Manufacturing Readiness Plan* is implemented. Program funds have been secured to begin implementing this plan.

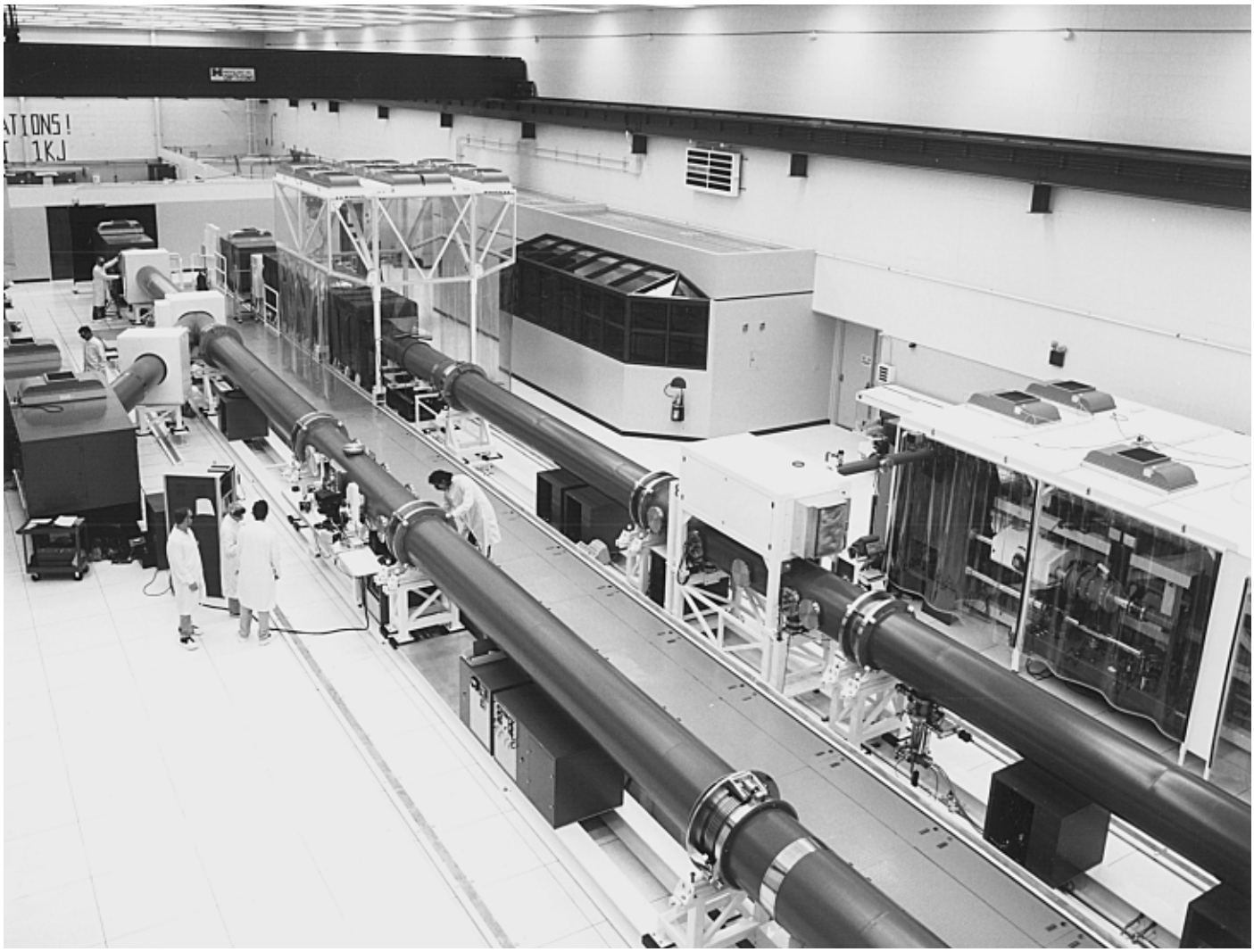

Figure 3. The Beamlet laser is a functional prototype of a NIF beam line.

Reviewing Cost and Schedule Estimates

The Department of Energy and an independent contractor (Foster Wheeler, USA) reviewed both costs and the detailed Integrated Project Schedule in March and April 1994 as part of the Independent Cost Estimate review. The following statements, taken from their report, validate the cost and schedule estimates for the NIF.

The coordination activities by the LLNL estimators and LLNL Purchasing personnel with the vendors are commendable, not only for the development of realistic and achievable cost estimates, but also in understanding the current development status of each component area.

The NIF Project has been well organized, planned, and developed, and all documents and data are of high quality. Full compliance with Department of Energy orders is evident.

The overall variance between the ICE (independent cost estimate review) and the P.O. (project office) total estimated cost is negligible.

Operating Costs After Construction

The NIF is part of the National Inertial Confinement Fusion (ICF) Program, whose missions include maintaining weapons-physics expertise, helping to ensure the safety, security, and reliability of our nation's nuclear weapons, investigating ICF as a possible energy source, and performing fundamental studies of high-energy-density science.

Funding for the core ICF Program is approximately $180 million to $200 million per year (in fiscal year 1996 dollars) during construction of the NIF (1996–2002). During construction, a portion of this funding will pay for continuing research on existing facilities, including the technology development leading up to NIF procurements and construction.

After 2002, the ICF Program will be devoted to obtaining ignition, to exploiting this unique facility, and to studying the next-generation ICF driver. At that time, the NIF operating costs will be $60 million per year (in fiscal year 1996 dollars) in addition to other elements of the core ICF Program. This amount will be applied to maintaining the facility, ensuring that it is operationally ready and capable of performing both the planned target experiment program (described in the CDR) and other target experiments. Other programs will support additional scientists and experiments for investigating basic physics, inertial fusion energy, weapons physics, and weapons effects.

Controlling NIF Costs and Schedule

Several factors assure that the NIF's cost and schedule will be controlled:

LLNL project experience—LLNL has built five large-scale laser facilities within cost and schedule estimates. All systems met or exceeded laser performance requirements.

Other project experience—Several other large projects have been examined, such as the Superconducting Super Collider in Texas, the Advanced Photon Source at the Argonne National Laboratory, and the Continuous Electron Beam Accelerator Facility in Newport News, Virginia. Several NIF managers met with these project managers to find examples to follow and pitfalls to avoid.

Project control systems—The NIF Project Control Systems are being structured to take advantage of the successes from both LLNL and the other large projects we've examined. A tracking system that will identify cost and schedule deviations before they become significant is being instituted. Also adopted is a scope and design control process that precludes the possibility of design changes without the appropriate level of scrutiny—a series of change control boards must review and approve system scope and design changes.

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